Part A

Classes(class, type, country, numGuns, bore, displacement)
Ships(name, class, launched)
Battles(name, date)
Outcomes(ship, battle, result)

(a) Give the class names and countries of the classes that carried guns of at least 16 inch bore

$$\pi_{class}\big(\sigma_{bore \geq 16}(Classes)\big)$$

class
Iowa
North Carolina
Yamato

(b). Find the ships launched prior to 1921

$$\pi_{name}\big(\sigma_{launched \leq 1921}(Ships)\big)$$

name
California
Haruna
Hiei
Kirishma
Kongo
Ramillies
Renown
Repulse

Resolution
Revenge
Royal Oak
Royal Sovereign
Tennessee

(c) Find the ships sunk in the battle of the Denmark Strait

$$\pi_{ship} \left(\sigma_{(battle="Denmark\ Strait"\ AND\ result="sunk")} (Outcomes) \right)$$

ship
Bismarck
Hood

(d) The "Treaty of Washington" in 1921 prohibited capital ships heavier than 35,000 tons. List the ships that violated the treat of Washington.

$$\pi_{name}(Ships \bowtie \sigma_{displacement \geq 35,000} (Classes))$$

name
Iowa
Missouri
Musashi
New Jersey
North Carolina
Washington
Wisconsin
Yamato

(e) List the name, displacement, and number of guns of the ships engaged in the battle of Guadalcanal.

$$R1 := \left(\sigma_{(battle="Guadalcanal")}(Outcomes) \right) \bowtie_{ship=name} Ships$$

$$R2 := R1 \bowtie_{R1.class=Classes.class} Classes$$

$$R3 := \pi_{(name,displacement,numGuns)}(R2)$$

name	displacement	numGuns
Kirishima	32000	8

(f) List all the capital ships mentioned in the database. (Remember that all these ships may not appear in the Ship relation).

$$\pi_{ship}(\pi_{ship}(Outcomes) \cup \rho_{ship}(\pi_{name}(Ships)))$$

ship
Arizona
Bismarck
California
Duke of York
Fuso
Haruna
Hiei
Hood
Iowa
King George V
Kirishima
Kongo
Missouri
Musashi

New Jersey
North Carolina
Prince of Wales
Ramillies
Renown
Repulse
Resolution
Revenge
Rodney
Royal Oak
Royal Sovereign
Scharnhorst
South Dakota
Tennessee
Washington
West Virginia
Yamashiro
Yamato

(g) Find the classes that had only one ship as a member of that class

$$R2 := \rho_{Ships2(name2,class2,launched2)}(Ship)$$
$$R3 := Ship \bowtie_{(class=class2 \; AND \; name<>name2)} Ships$$
$$R4 := \pi_{class}(R2) - \pi_{class}(R3)$$

class

(This is an empty table)

(h). Find those countries that had both battleships and battle cruisers

$$R1 = \rho_{R1}(Classes)$$
$$R2 = R1 \bowtie_{R1.class=Classes.class \ AND \ R1.type <> classes.type} (Classes)$$
$$\pi_{country}(R2)$$

country
Janpan
Gt.Britain

(i) Find those ships that "lived to fight another day"; they were damaged in one battle, but later fought in another.

$$R1 := Battles \bowtie_{Battles.name=Outcomes.battle} Outcomes$$
$$R2 := \rho_{R2(name2,date2,ship2,battle2,result2)}(R1)$$
$$R3 := R1 \bowtie_{(ship=ship2 \ AND \ battle1<>battle2)} Ships$$
$$R4 := \sigma_{(result="damaged" \ AND \ date<date2)}(R3)$$
$$R5 := \pi_{(result=ship}(R4)$$

ship
South Dakota